RESEARCH HIGHLIGHTS

Technical Series 01-141

THE SUSTAINABLE HOME WATER SYSTEM

Introduction

The Sustainable Home Water System (SHWS) is a residential water supply system installed in the Alberta Sustainable Home/Office (ASH), a demonstration house in Calgary, Alberta. The SHWS incorporates subsystems for rainwater collection, potable water treatment and distribution, greywater heat recovery, and greywater treatment and reuse. The purpose of SHWS is to reduce residential water consumption and demonstrate an environmentally responsible alternative to municipal water supply and wastewater treatment.

The SHWS research project had four objectives:

- To design an autonomous home water system that includes rainwater collection, storage and treatment components, greywater heat recovery, and a greywater treatment and recycling system.
- To install the SHWS at the Alberta Sustainable Home/Office as a demonstration prototype.
- To monitor and evaluate the performance of the SHWS and the greywater heat exchangers.
- To determine the viability of the SHWS in the Canadian Housing Industry as a retrofit and for new home installations.

Research Program

The design process

As a first step in designing the SHWS, the researchers determined the total water demand in the SHO home/office by summing the average volumes of water to be used by each appliance and fixture for a typical family of four that practises water conservation. To help size the components of the SHWS, including the two greywater heat exchangers, the total water demand was further broken down into the potable and non-potable, as well as the hot and cold water requirements.

Calculations of the potential annual rainfall collection indicated that water collected from the roof could easily meet the household demand for potable water. The demand for non-potable water could be supplied by greywater treated to reuse standards, relying on treated rainwater as a backup source.

The Sustainable Home Water System

The major components of the SHWS included subsystems for rainwater collection and storage, potable-water treatment and supply, a composting toilet, greywater collection and heat recovery, and greywater treatment and reuse supply. The waterless composting toilet and an ultra-low-flush vacuum toilet eliminated blackwater generation from the system, reducing the household's water consumption by approximately 165,700 litres a year.

The rainwater collection and storage system consisted of the roof, rain barrels, underground cisterns and underground pipes. Rainwater from the storage system was treated on demand when potable water was needed at the kitchen tap, the dishwasher and one bathroom sink. The treatment process involved slow sand filtration and ultraviolet disinfection.

Two types of heat exchanger protoypes—counter current for continuous flow greywater sources (that is, showers) and drum storage for non-continuous flow sources (that is, bathtub and clothes washer in the demonstration home)— reclaimed heat from hot and warm greywater sources.

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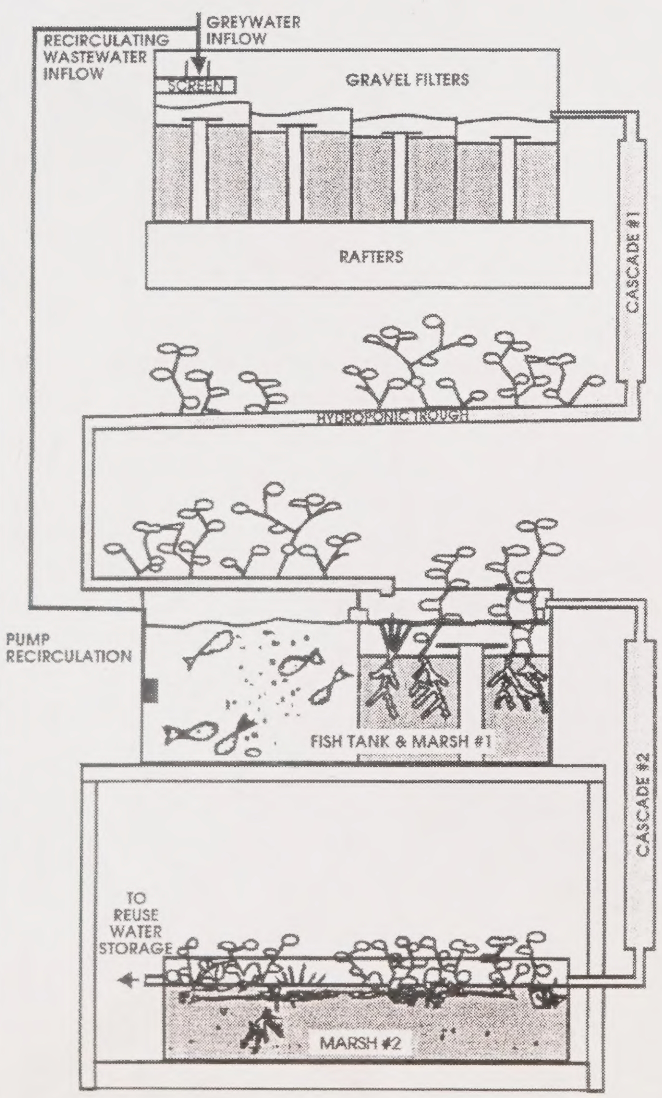
Treatment of the greywater occurred in a greenhouse, where three systems—slow sand filtration, subsurface soil bed irrigation and a greywater garden wall—operated in series to emulate a natural water purification process. The treated greywater was stored and then treated again with ultraviolet irradiation when needed as reuse water.

The slow sand filtration removed 99-100 per cent of the total and fecal coliform bacteria and 99.9-100 per cent of viruses as well as heavy metals. In the soil box subirrigation system, plant roots absorbed water and nutrients, and soil bacterial activity helped purify the water. The soil box contained edible vegetables, fruit flowers and herbs, native species and plants useful for medicinal purpose or air and water purification.

Figure 1: Schematic of the greywater garden wall



The third subsystem—the greywater garden wall—functioned as a balanced ecosystem of living organisms (bacteria, algae, zooplankton, plants, snails, prawns, whitecloud minnows and tilapia or other species of edible fish). In addition to reducing the amount of organic wastes in the greywater, this biologically active garden wall demonstrated the feasibility of domestic food production through hydroponics and fish and crustacean culture.

Water quality monitoring

In the monitoring phase of the project, the researchers took potable water samples from a series of locations to determine whether any changes in the water quality had occurred through the treatment process. Sampling took place at the downspouts, the underground cistern, pre and post slow sand filtration, and the kitchen faucet. The reuse water was also sampled.

Greywater heat exchanger monitoring

The investigators also evaluated the performance of the two heat exchanger prototypes by determining the temperature and thermal efficiencies of each unit. Using additional information, they then calculated utility cost reductions, construction costs and simple payback.

Findings

Potable-water results

The potable water supply at the ASH home/office was acceptable for human consumption according to the parameters tested. However, mixed results at various points along the system indicated where and how the SHWS could be improved.

The first tests of the rainwater (May 1996) revealed a high degree of foaming, extremely high levels of total organic compounds but no detectable levels of volatile organic compounds. Both the pH and the conductivity results were also high, compared with typical rainwater characteristics. A possible reason for these results could have been leaching of organic compounds from the elastomeric polymer roof surfacing into the rainwater. Other parameters, except for temperature and pH, were within acceptable limits.

The water at the underground cistern showed acceptable levels of pH, nitrate, sulphate and iron. However, temperature, total dissolved solids, turbidity, fecal coliform and total coliform showed mixed results. There were also elevated levels of total alkalinity and phosphorous.

Water quality at the slow sand filter was within acceptable limits, with the exception of temperature. In addition, the phosphorous content was elevated from the cistern water value. At the kitchen faucet, the water conformed to the Canadian Drinking Water Quality Guidelines (1996) for all parameters except temperature.

Greywater results

Monitoring of the greywater supply took place in March and October 1998. It showed that all the parameters tested, except BOD^5, were greater than typical greywater characteristics but within acceptable ranges for the residential wastewater properties.

The characteristics of the reuse water, other than total suspended solids, conformed to the non-potable water guidelines of several states within the U.S.A. There are no Canadian greywater or reuse water guidelines.

Heat exchanger results

Monitoring of the heat exchanger prototypes combined with subsequent calculations indicated that the heat reclaimed from the greywater was lower than what was expected. The counter current prototype contributed 7.4 per cent of the required hot water heating, while the drum storage prototype contributed 4.4 per cent. More efficient, in-series operation of the greywater heat exchanger system accounted for 16.8 per cent of the heat required for the hot water.

Possible reasons for the poor performance of the heat exchangers included constraints related to location of the retrofit, incorrect plumbing configurations and problems with the monitoring instruments. The water conservation practices of the occupants and the design of the SHWS, particularly the low ambient temperature of the inlet water, also limited the temperature gain potential.

Implications for the housing industry

The authors conclude that the SHWS offers a feasible alternative to expensive and inefficient, large-scale centralized water and wastewater treatment systems. They suggest that if SHWS design principles were incorporated into common practice in Calgary, for example, residential potable water consumption could be reduced by 78 per cent by using conservation practices and common sense, and up to 97 per cent if reuse water was utilized to supply non-potable water demands.

They also believe the SHWS is marketable as a cost-effective, environmentally friendly, safe, home water system, the components of which can be installed in either retrofit or new home applications. Many of the system's components are commercially viable or available today, are affordable and have favourable payback periods.

Each individual application of an SHWS would be unique, reflecting the preferences of homeowners. Therefore, manufacturers, retailers and builders could market the SHWS as a customizable set of components that can be adapted and combined for a particular application.

The report also suggests there would be many benefits to incorporating the SHWS into Canadian homes. These include:

- improvement of conventional water and wastewater treatment systems;
- reduction of infrastructure, operation and maintenance costs;
- conservation of fresh water resources;
- protection of the environment;
- enhancement of environmental awareness; and
- reduction of utility bills.

The SHWS could be especially beneficial for remote or rural areas; acreages with septic systems; agricultural applications; environmentally sensitive locations; climatic zones with scarce fresh water resources; areas with contaminated water sources; and autonomous or sustainable communities as well as environmentally conscious individuals.

However, the lack of greywater and reuse guidelines in Canada is a barrier to the widespread adoption of the SHWS. The report urges the appropriate government bodies to develop standards so Canadians can benefit from this potential resource and maintain safety and health standards.

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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